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MEMORANDUM

To: Theresa A. Dunham; Somach, Simmons & Dunn

From: John Schaap, Steve Bommelje

Subject: Costs to Retrofit Existing Dairies That Do Not Have Tier 1 or Tier 2 Lagoons.

Date: August 5, 2013

This memo estimates the costs to retrofit existing dairies that have do not have Tier 1 or Tier 2 lagoons for a range of dairy sizes. It also discusses other cost drivers that could impact retrofit projects.

Qualifications

John Schaap graduated from California Polytechnic State University, San Luis Obispo, California with a B.S. in Agricultural Engineering. He also holds an M.S. in Biological and Agricultural Engineering from the University of California, Davis, California.

Mr. Schaap is a registered agricultural and civil engineer in the State of California (license numbers AG 563 and C 61754). He has been in private practice as a consulting agricultural and civil engineer since January 2001, and has specialized full-time in dairy related matters in the San Joaquin Valley since that time. Mr. Schaap is a principal engineer with Provost and Pritchard Consulting Group (P&P).

Provost and Prichard Consulting Group has been meeting agricultural design and consulting needs in Central California since 1968. We have offices in Fresno, Bakersfield, Visalia, Clovis, Modesto, and Los Banos. Our staff includes licensed agricultural and civil engineers, as well as licensed geologists and other technical staff experienced in dairy work.

P&P acquired the dairy design firms of Valley Management Systems, Inc. (VMS) and EJS & Associates, Inc. in 2004, enfolding key personnel into the company to strengthen our dairy business. Since then, our firm has been at the forefront in assisting dairy clients achieve compliance with new or changing regulatory requirements, for both new and existing facilities.

Within approximately the last 10 years, P&P has designed and assisted in the certification of over 50 dairy lagoons in the Central Valley. These have included approximately 27 sites with lagoons meeting the 10% clay soil requirement, 7 sites that followed the NRCS Appendix 10D compacted clay liner guidelines, 10 sites with single liners, mostly using high density polyethylene (HDPE) material; and 8 sites with double HDPE liners with leachate collection and recovery systems (LCRS). Our firm has many more dairy liner projects that are currently in the design stage. The above projects do not include other similar wastewater impoundments that have been engineered for food processors, wastewater treatment plants, or other similar facilities, going back further in P&P's history. In the last ten years, approximately 14 of our technical staff have worked on lagoon projects.

Cost Estimates

We have prepared a range of cost estimates for retrofitting or rebuilding dairy lagoons with new liners. See Table 1. The estimates are for four sizes of dairies within a range typically found in the Central Valley: 300 milk cows (MC), 750 MC, 1,500 MC, and 3,000 MC. For each herd size we have calculated costs for four possible scenarios. These scenarios represent the four possible combinations of the following variables:

1) Liner design: single (Tier 2) or double (Tier 1) liner;
2) Lagoon location: new location or build within the current footprint of an existing lagoon location.

In order to keep the analysis consistent through the range of herd sizes, some baseline assumptions were used in sizing lagoons. These include the following:

- Weather conditions found in the Tulare and Kings County area;
- A 5:1 rectangular shape with a total depth of 20 feet;
- A constant rate of dairy barn water generation of 50 gallons per milk cow per day;
- 120 day winter storage period from November 1 to March 1; and,
- Overall storage capacity ratio (actual/required) between 100% and 105%.

Cost estimates assume a completely below ground lagoon with more than 5 feet of clearance to highest anticipated groundwater. Costs for design, earthwork, lining, and construction quality assurance and reporting are included.

Option of Single or Double HDPE Liner Design

The Dairy General Order stipulates that all new or modified lagoons meet the conditions described as a Tier 1 or Tier 2 lagoon. The Tier 1 lagoon is a 60-mil HDPE double liner with a leachate collection and recovery system. The Tier 2 option does not specify the liner material needed; however, it requires groundwater modeling as part of the design, and proposed ongoing monitoring that demonstrates protection of ground water. At this time, when the conditions are such that a single liner is possible, we have found it necessary to design a liner consisting of one layer of 60-mil HDPE over a one-foot thick soil layer with low permeability. Thus, for the Tier 2 case, this is what we have used as the basis of our estimate.

HDPE liner material with proper care and maintenance should have a service life of 20 to 30 years. We have not calculated a life cycle cost, but simply a single installation cost. Dairy facilities can have a useful life that exceeds the liner life, and thus a liner may need to be reinstalled at least once over the useful life of a dairy.

Option of New Location or Existing Location

The existing location option assumes that the size of the current lagoon is adequate, requiring only the excavation of several feet of organic laden soil, and contouring of the side slopes. An existing location requires the removal of liquid and solid manure prior to any construction work. Costs were included for that effort.

The new location option includes estimates for full excavation (assuming stockpiling nearby) and a location within close proximity in order to connect to the existing wastewater system. Here, the cleanout of manure from the old lagoon could be performed at any time but will at some point need to be performed to close the lagoon. If the old lagoon was allowed to dry, the cleanout costs could be reduced by handling the manure in a dry state. So we have included the “liquid and wet solid” cleanout cost in parentheses in Table 1 to provide an understanding of the range of costs that could be expected to clean the old lagoon to close the project.

Table 1. Costs to retrofit lagoons based on dairy size and retrofit type.

	Existing Location*	New Location	Wet Cleanout**
300 MC, 2.1 ac lagoon			
Single	$198,000	$180,000	(+$37,000)
Double	$270,000	$252,000	(+$37,000)
750 MC, 3.4 ac lagoon			
Single	$300,000	$275,000	(+$78,000)
Double	$425,000	$399,000	(+$78,000)
1,500 MC, 6.0 ac lagoon			
Single	$521,000	$482,000	(+$171,000)
Double	$753,000	$714,000	(+$171,000)
3,000 MC, 10.7 ac lagoon			
Single	$948,000	$887,000	(+$357,000)
Double	$1,383,000	$1,321,000	(+$357,000)

* An existing location estimate includes the cleanout of liquid and solid manure from the lagoon before construction can begin.

** A new location estimate does not include any cleanout cost of the old lagoon. This wet cleanout cost could be expected if performed while water is in the old lagoon.

Issues

There are many issues that may arise with the retrofitting or replacement of a lagoon. Each dairy has a different set of circumstances that may require additional effort to be expended in locating and designing a lagoon.

<u>Tier I Lagoon (Double Liner) vs. Tier 2 Lagoon (Single Liner)</u>
From the estimated costs shown in Table 1, a single liner appears to be a more cost-effective option. However, to obtain approval for a single liner, the design must show that groundwater will not be impacted via a model, and a monitoring system must be installed and maintained.

Groundwater models that are currently used to predict the performance of a liner are simplified models that are highly conservative. Conditions contributing to passing the modeling are low nitrate levels in background groundwater samples, high velocity groundwater flow beneath the site, low permeability soils, and minimal defects in the post-construction liner.

Currently, we are finding that most sites do not pass the simplified model and a single liner is thus not an eligible option. If a detailed modeling effort were performed, the modeling cost could equal the cost of the extra liner layer in question, without a guarantee of positive results. Thus, detailed modeling is generally not pursued at this time.

A single liner requires some type of accompanying groundwater monitoring, as noted above. Monitoring wells focused around the subject lagoon (outside of the representative monitoring program) are the typical monitoring system proposed. When depth to first encountered water is great, the cost for installing monitoring wells increases and other groundwater quality influences can possibly be mixed in the samples taken, obscuring the conclusions that can be drawn.

In Table 1 above the single liner option includes costs for installing lagoons, but does not include costs for monitoring. These can include the installation of monitoring wells, sampling and laboratory analysis on an ongoing basis, data assessment and analysis, and technical reports. These costs are not insignificant and can cost tens of thousands of dollars for well installation and hundreds to thousands of dollars per year in ongoing costs.

New Location vs. Existing Location

To rebuild a lagoon in the current location, provisions must be made to divert and contain the daily barn water generation (and any rainfall runoff) temporarily during the construction period. In many cases this may not be feasible, leading to the only other option, to build in a new location.

To compact the soil for structural support and installation of the HDPE liner, the side slopes must typically be 2:1 (horizontal: vertical) or flatter, depending on soil properties. Typical existing lagoon slopes are 1.5:1 or steeper. Therefore a larger lagoon footprint is likely to be needed to maintain the storage volume. In addition, the retrofit will need to provide 5 to 6 feet of additional room around the lagoon perimeter for an anchor trench to hold the liner material. Many lagoons are positioned near other structures on the dairy and this additional space may not be available.

Relocating the lagoon to a new area may require county permit changes if the location is outside of the established footprint of the dairy. Such changes are likely to trigger the need to comply with the California Environment Quality Act (CEQA), which could require the preparation of a mitigated negative declaration or an Environmental Impact Report (EIR). Other land use permits may also be triggered. Additional costs to comply with local land use permitting processes (including CEQA compliance) could possibly ranging between $30,000 to $100,000 or more.

The estimates in Table 1 indicate approximately how many acres the new lagoon is expected to occupy. In some cases, locating the new lagoon near the existing lagoon is infeasible and additional costs may be incurred to route the wastewater to a more distant location. In some cases, significant infrastructure, such as a pump station, may be required.

Highest Anticipated Groundwater

In shallow groundwater areas, this can be a significant issue complicating lagoon design. In other areas where the groundwater has deepened, but historically has been within 5 feet of the invert, it can present a physical or regulatory risk.

In order to quantify the highest anticipated groundwater to plan lagoon construction, areas with shallow groundwater require study on factors influencing the groundwater level, including influences from irrigations, ditches, or rainfall. This could require a complete year of study, periodically recording depth to groundwater in the intended site area, followed by a report from a geologist documenting the findings and recommendations. Conclusions may dictate reducing lagoon depth, building an above ground lagoon, and/or artificially controlling the water table with a tile drainage system.

Above Ground Lagoon

The above ground lagoon can be a good option for a new lagoon, from the perspective of minimizing the volume of soil that must be moved. However, in many areas, these are required due to high groundwater conditions.

Depending on the available soils, embankment height may be limited by engineering constraints. If below grade depth is limited, a deep lagoon (and efficient use of liner area) may not be possible at all. For a given storage volume, decreasing the depth of the lagoon will require increasing the footprint and corresponding liner costs. Thus, the cost for an above ground lagoon could be higher than identified in Table 1, as a function of the depth of the lagoon. There could be a decrease in earthwork costs, as less total volume of earth may need to be moved to provide the same storage volume; however, this is offset by the increased cost of placement of compacted fill in above ground embankments.

Using the 750 milk cow dairy case as an example, an above ground lagoon with only 12 feet of total depth increases the foot print by 1.2 acres and adds an additional cost of approximately $34,000 to the single liner and $83,000 for the double liner installation.

Manure and Sand Separation

New lagoons lined with thin layers of synthetic material are vulnerable to damage from lagoon cleaning equipment. A small hole in the liner can allow wastewater to get underneath. The wastewater naturally produces carbon dioxide and methane, byproducts of anaerobic digestion. The trapped gases under the liner can accumulate (if not vented) and eventually tend to float the liner to the surface, introducing stresses in the liner, leading to more liner damage, more wastewater under the liner, and yet more trapped gases. Thus, a minor nick or puncture of a 60 mil layer can lead to a major incident, requiring the replacement of the entire liner. Costs could approach what is estimated in Table 1 for an existing lagoon relining operation. Accordingly, it is very important to minimize liner exposure to equipment and to reduce cleanings as much as possible.

Manure solids separation systems are common on dairies. Some systems still allow a significant amount of solids into the lagoon because of various issues. Good solids separation can be an important factor enhancing the useful life of a liner. Thus, when installing a lined lagoon it is important to consider or reconsider manure separation. Adding a new screen separator and concrete drying pad can cost from $180,000 for a smaller dairy to $400,000 or more for a larger dairy. These costs are not included in Table 1 but may be necessary on many dairies to properly maintain and operate lagoons with synthetic liners.

Sand or dirt removal is also an important consideration. Sand can be introduced to the manure stream from bedding, feed, track-in from corrals, or other sources. Sand settling lanes or traps are a good solution, but must be considered during design to account for location, elevation, and gravity flow constraints.

Increased Rainfall and Storage Period

The estimates in Table 1 considered the weather conditions representative within Kings and Tulare Counties. Other areas to the north have more rainfall and may require a longer storage period, both of which require additional storage volume. Providing greater storage volume results in increased costs over what was estimated in Table 1.

Using the 750 milk cow dairy again, changing the rainfall numbers to what is expected in the northern Sacramento Valley near Orland, the 750 milk cow dairy needs an additional 1.7 acres and costs are increased by roughly 50%. Adding an additional month of storage adds approximately another 7% to the cost.

Conclusion

The estimated costs provided in Table 1 are based on the minimum anticipated cost for the construction of an HDPE lined lagoon for a range of dairy sizes. These estimates are conservative (at an estimated higher cost) based on standardized assumptions that were outlined. However, when compared to each unique dairy situation additional cost drivers can easily increase the overall cost. These additional costs outlined in the Issues section can include location, groundwater conditions, manure and sand separation systems, higher rainfall areas than the south valley, and the length of the storage period.